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Estimating of Heterosis and Combining Ability for some Egyptian Cotton Genotypes Using Line X Tester Mating Design

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ABSTRACT

This investigation was carried out at Sakha Agric. Res. Stat. KafrelSheikh, Agric. Res. Centre, Egypt, during 2014 and 2015 growing seasons. A study was undertaken on some genotypes of Egyptian cotton (*Gossypium barbadense* L.) to estimate the mean performance, heterosis over better parent (heterobeltiosis), combining ability and type of gene action for some earliness, yield and its components traits in some Egyptian cotton genotypes by using line x tester mating design between seven cotton genotypes i.e., Giza 45, Giza 67, Giza 68, Giza 85 Giza 86, Dandra and Giza 92 which used as lines, and two foreign varieties; Pima S_6, Karsheneski-2 as well as promising cross Giza 89 x Pima S6 were used as testers. The analysis of variance indicated that the mean squares of genotypes for all studied characters were significant and highly significant, indicating the present of considerable amount of genetic variability among genotypes, parents and hybrids. Mean squares of general combining ability general combining ability (GCA) for lines found to be signification for most investigated characters. On the same time general combining ability variance for testers (female parents) were also significant for earliness index , boll weight, seed and lint yield / plant , seed index and lint index. These revealing important of additive and additive x additive type of gene effect on such characters. While, the mean squares of specific combining ability (SCA) were also significant for all yield and it's attributed characters, except for first fruiting node, revealing that non-additive (dominance or epistasis) effects in the inheritance of these traits was detected. The data illustrated that the variance due to general combining ability was lower than variance of specific combining ability and the ratio of σ^2 GCA / σ^2 SCA was less than unity for all studied characters, indicating preponderance of non–additive gene action (dominance or epistasis), which is an important in exploitation of hetorsis through hybrid breeding. The cross combination Kar2 x Giza 85 followed by Kar2 x Giza 67 surpassed all cross combinations for earliness index. The cross combinations Pima x 67, Pima x 86 and Pima x 68 exhibited mean values and exceeded other combinations for yield and its components traits. The cross combination Kar2 x G.67 recorded the best values of heterobeltiosis for all earliness traits followed by Kar2 x G.86. The cross combination Pima x G.68 recorded significant desirable values over better parents heterosis for seed cotton yield/ plant, lint yield and lint percentage. Karshenesky2 was the best combiner for earliness index and seed volume. Giza 67 was the best general combiner for earliness index. The parent Giza 68 recorded significant positive general combining ability value for seed cotton yield/ plant. However, the parent Giza 85 followed by Dandra gave the best general combining values for lint yield / plant and lint percentage. The cross combination Kar2 x Giza 92 was the best combination for most earliness characters. However, the cross combination Pima x 67 followed by Pima x Dandra observed highest positive significant SCA effects for most yield characters.

Keywords: Cotton, heterosis, combining ability, gene action, line x tester.

INTRODUCTION

To improve cotton yield, early mature with acceptable fiber properties have been a primary objective of cotton breeders. Therefore, the selection of parents to serve as apparent in hybridization program is one of the most important decisions for a plant breeder. Selection suitable parents is one of the most important criteria used to find the most promising crosses and increase the efficiency of the breeding programs.

Different statistical and biometrical procedures employed for characterization of variability of the plant populations have become important auxiliary tools for the definition of crosses. Line x tester analysis is one of the most efficient procedures for identifying parents with potential use for crosses. It can be used to estimate general and specific combining ability. The concept of combining ability plays a significant role in crop improvement, since it helps the breeder to determine the nature and magnitude of gene action improved in the inheritance characters, and it useful in selection of desirable parents for explanation of hybrids and transgressive expirations (Ashokkumar and Ravikesavan , 2010).

Earliness is an efficient quantitative character and it is affected by genetic–physiological composition of plants and environmental conditions (Kassianenko *et al*., 2003). Earliness of the crop maturity is an important objective in cotton , in the avoidance of frost damage insect and disease build up , soil moisture depletion and weathering of the open cotton , while, the other advantage of use cotton in to multicroping , allowing rotation with a winter crop such as wheat , Spring wheat is the staple food of people in Egypt , and thus the crop is grown on an extensive area , following different rotation systems , to meet the demand of food supply to increasing population. It has been observed that wheat –cotton rotation (Panhwar, 2007). Therefore, this investigation was aimed to: 1)- Obtain more information of the genetic variability of plant characters related to earliness, yield and its components, 2)- Estimate of heterosis over better parent and general and specific combining abilities for the studied characters, and 3)- Estimate the relative importance of the evaluated characters.

MATERIALS AND METHODS

The investigation was carried out at Sakha Agriculture Research Station, ARC Egypt during two growing seasons of 2014 and 2015. The materials used in this study included ten cotton genotypes i.e., Giza 45, Giza 67, Giza 68, Giza 85, Giza 86, Dandra and Giza 92 which used as lines, two foreign varieties; Pima S_6, Karsheneski-2 and promising cross Giza 89 x Pima S6, were used as testers. The pedigree, origin, and descriptions of main characters of the ten parents were presented in Table 1. The seeds of all genotypes were obtained from Cotton Research Institute (CRI), Agriculture, Research Center, (ARC), Egypt.

Line x tester analysis is an extension of this method in which several testers are used (Kempthorne, 1957). The latter design provides an information about general and specific combining ability of parents and it was helpful for estimating various types of gene effects.

In 2014 season, the single crosses between ten parental genotypes were made by using seven Egyptian cotton varieties as lines, i.e., Giza 45, Giza 67, Giza 68, Giza 85 Giza 86, Dandra and Giza 92. While, the two foreign genotypes;, Pima S_6, Karsheneski-2 and promising cross Giza 89 x Pima S6 were used as testers to produce 21 F_1s seeds, and the parental varieties were also self-pollinated to obtain selfed seeds.

Table 1. Names, pedigree, origin and the main characters of the used cotton parents in this study.

Genotypes	Pedigree	Origin	Main characters
Lines :			
1- Giza 45	G. 28 x G. 7	Egyptian	An extra long staple, extra fineness, strong lint, high bundle's strength and characterized by low yield
2- Giza 67	G. 53b x G. 30	Egyptian	Long staple. It characterized by high yield and early maturity
3- Giza 68	G. 56 x G. 36	Egyptian	Extra-long staple. It characterized by high yield and early maturity
4- Giza 85	G. 67 x C.B. 58	Egyptian	Long staple. It characterized by high yield and creamy lint high lint strength.
5- Giza 86	G. 75 x G. 81	Egyptian	Long staple. It is characterized by high yield, boll weight, lint percentage, plant height and late maturity
6- Dandra	G. 31 (zagora)	Egyptian	long staple. It is characterized by early maturity
7- Giza 92	G.84x (G. 74 x G. 68)	Egyptian	New extra-long staple variety . It is characterized by high lint strength and yield.
Testers:			
1- Pima S_6	(5934-23-2-6) x (5903-98-4-4)	American	A long staple. It is characterized by high lint percentage, lint index and plant height
2- Karsheneski-2	Russian x Egyptian cotton	Russian Egyptian	It is brancheless, low in yield, lint percentage, boll weight, leaf area index, position of first fruiting node and early maturity.
3- Giza98 x Pima s6	-	Egyptian	Promising cross early in maturity

In 2015 season, the F1's seeds for the 21 crosses and their 10 parents were sown in randomized complete blocks design (RCBD) experiment, with three replications to evaluate the different genotypes (entries). Each replicate contained 31 plots, and each plot contained single ridge, 4.5 m length and 0.65 m width. Hills were spaced at 30 cm apart to give 15 hills/ridge. At seedling stage hills were thinned to keep constant stand of two plants/hill.The recommended cultural practices were applied in their times. Randomly sample of ten plants were harvested from every plot to determine both yield and its components and fiber properties.

The studied traits:

A: - Earliness traits: 1) - Days to first flower (DFF), 2) - Position of first fruiting node (FFN) and 3) - Earliness index (EI)

B:-Yield and yield component traits: 1)-Seed cotton yield/plant (SCY/plant, g), 2) - Lint yield/plant (LCY/plant g), 3)- Lint percentage (LP %), 4)- Boll weight (BW, g), 5.Seed index (SI, g), and 6.Lint index (LI, g).

Statistical analysis:

A regular analysis of variance of a randomized complete block design (RCBD) was analyzed. The mean squares of genotypes and replications for all studied traits were tested for significance according to the F-test. The form of the analysis of variance as outlined by Cochran and Cox (1957).

Line x tester analysis as proposed by Kempthorne (1957) was deviated to partitioning the genetic variation of the F_1 top-crosses due to lines, testers and their interaction, provide informations about general and specific combining ability of the parents and crosses, in addition to also provide the estimates of various types of gene effects.

The values of heterosis were determined as the percentages deviation from the F_1's hybrids over the average of the mid-parents (M.P) and above the better-parents (B.P). Therefore, the values of heterosis could be estimated from the following equations:

$$\text{Heterosis over mid - parent}(\overline{M.P})\% = \frac{\overline{F1} - \overline{M.P}}{\overline{M.P}} x100$$

$$\text{Heterosis over better parent}(\overline{B.P})\% = \frac{\overline{F1} - \overline{B.P}}{\overline{B.P}} x100$$

The significance of heterosis was tested, using the least significant difference value (L.S.D.) at 0.05 and 0.01 levels of probability, according to the formula of Steel and Torrie (1980), as following:

$$\textbf{LSD. for mid parent heterosis} (\overline{F_1} - \overline{M.P}) = t(3MSe/2r)^{\frac{1}{2}}$$

$$\textbf{LSD for better parent heterosis} (\overline{F_1} - \overline{BP}) = t(2MSe/r)^{\frac{1}{2}}$$

RESULTS AND DISCUSSION

Analysis of variance:

The analysis of variance Table2 indicated that the mean squares of genotypes for all studied characters were significant or highly significant, indicating the present of considerable amount of genetic variability among genotypes, parents and hybrids. The variations due to parent's hybrids were also highly significant for all studied characters. However, the variation due to parents *Vs* hybrids was also highly significant for most characters under investigation, indicating the heterotic response for these characters.

Table 2. Mean squares of earliness traits, yield and its components

S.O.V.	DF	Earliness traits			Yield and yield components					
		dFF	FFN	EI	BW(g)	SCY/P(g)	LCY/P(g)	LP %	SI(g)	LI(g)
Rep.	2	4.72	0.39	24.14	0.04	599.29	47.42	3.70	0.17	0.09
Geno	30	59.24**	1.42**	489.95**	0.39**	359.9**	77.6**	8.69**	3.87**	2.39**
Cross	20	10.03**	1.05	382.31**	0.45**	308.4**	70.9**	8.32**	2.73**	1.90**
Line (gca)	6	15.93**	1.09	1010.00**	0.96**	354.8**	99.0**	11.3**	6.8**	4.33**
Tester (gca)	2	1.00	0.97	160.39**	0.57**	262.0**	63.3**	1.41	1.73**	0.63**
L x t (sca)	12	8.59**	1.04	105.44**	0.18**	292.9**	58.1**	7.98**	0.85**	0.90**
Parent	9	72.80**	2.39**	674.30**	0.26**	471.1**	90.6**	10.26**	5.60**	3.20**
Line(p)	6	32.54**	2.08**	280.91**	0.11**	408.9**	80.1**	9.50**	1.91**	1.49**
Test(p)	2	26.78**	1.44**	1099.80**	0.61**	891.4**	160.2**	9.77**	19.47**	9.57**
L(p) vs t(p)	1	406.41**	6.10**	2183.64**	0.43**	3.95	14.87	15.8**	0.01	0.75**
Peranet VsHybird	1	921.38**	0.00	983.78**	0.23**	389.4**	94.9**	1.80*	11.24**	4.68**
σ^2gca	-	0.0375	0.0002	7.2099	0.4034	0.3325	0.0090	0.0488	0.0261	0.0070
σ^2sca	-	1.8205	0.1215	27.1217	72.3002	15.0520	2.4556	0.1441	0.2438	0.0482
σ2GCA/ σ2SCA		0.020599	0.001646	0.265835	0.00558	0.02209	0.003665	0.338654	0.107055	0.145228
Error	60	2.84	0.59	28.28	0.03	75.23	11.70	0.62	0.35	0.15

***Dff=days to first flower   * ffn= first fruting node   * EI= Earliness index   *BW= Boll Weight   * SC/P= Seed cotton /plant**
*** LY/P= Lint yield/plant   * LP= lint percentage   * SI = Seed index   * LI= Lint index**

Mean squares of general combining ability (GCA) for lines Table2 found to be signification for most investigated characters. On the same time general combining ability variance for testers (female parents) were also significant for earliness index , boll weight , seed and lint yield / plant , seed index and lint index. These revealing the importance of additive and additive x additive type of gene effect on such characters. While the mean squares of specific combining ability (SCA) were also significant for all yield and it's attributed characters, except for first fruiting node, revealing that non-additive (dominance or epistasis) affects in the inheritance of these traits.

The data in Table2 illustrated that the variance due to general combining ability was lower than variance of specific combining ability (SCA) and the ratio of σ^2 GCA / σ^2 SCA was less than unity for all studied characters, indicating preponderance of non–additive gene action (dominance or epistasis), which is an important in exploitation of heterosis through hybrid breeding. The previous results are in accordance with those obtained by Iqbal *et al.* (2005), Preetha and Raveendran (2008), Basal *et al,* (2009) and Baloch *et al*. (2017).

From the previous results it is interest to note that, since the mean squares were significant for general and specific combining ability and the majority for line x tester specific combining ability (SCA). Since general combining ability reflects parental performance and is the results of additive gene effect and additive x additive type of gene effect. However, specific combining ability (SCA) reflected the average performance of hybrid progenies and it outcome of dominance and dominance x dominance gene effect. Thus, the results reflect the importance of non–additive type of gene effect (dominance or epistasis). Selection of desired hybrid progeny hybrid must be made on the basic of dominance or epistasis gene effects which are in pronounced and preponderant for the significant characters under investigated. Recurrent selection with intermitting methods could be used in later generation to exploitation the non-additive gene effects. Similar conclusions were recorded by Basbag *et al.* (2007), El Mansy *et al*. (2014) and Baloch *et al*. (2015).

The proportional contribution of lines, testers and their interactions to the total variance for different characters under investigation are presented in Table 3. The results revealed that the maximum contribution to the total variance for most characters was made by line x tester interaction. Furthermore, the contribution of the line parents were higher than of the interaction for earliness index, boll weight, seed index and lint index.

Table 3. Proportion contribution of lines, testers and their interaction for earliness yield and its components

	Earliness traits			Yield and yield components					
Cha.	**dFF**	**FFN**	**EI**	**BW(g)**	**SCY/P(g)**	**LCY/P(g)**	**L P%**	**S I(g)**	**L I(g)**
Con L %	47.62	31.16	79.26	63.19	34.52	41.89	40.79	74.89	68.35
Con T %	1.00	9.23	4.20	12.59	8.50	8.93	1.69	6.34	3.31
Con. L*T %	51.38	59.61	16.55	24.22	56.99	49.18	57.52	18.77	28.34
	DFF	FFB	EI	BW	SC/P	LY/P	LP	SI	LI

***Dff=days to first flower * FFN= Position of first fruiting node * EI= Earliness index * BW= Boll Weight * SC/P= Seed cotton /plant * LY/P= Lint yield/plant * LP= lint percentage * SI = Seed index * LI= Lint index**

Mean performance:

Mean performance was considered as the first important selection index in the choice of parents and the parents with high mean performance will results in superior hybrids. (El–Hashash, 2013).

The mean values of the studied characters of ten parents (7 lines+ 3 testers) illustrated in Table 4. The data revealed that the ten parents were significantly deferent in earliness characters. The Russian genotype (karshenky2) surpassed all cotton parents for earliness characters Table 4 showed decrease in days to first flower and first fruiting branch with increased in earliness index followed by the promising cross Giza89 X Pima S6. The Upper Egypt parent, Dandra, showed somewhat earliness characters. On the other side, the commercial variety Giza86 showed the reverse trend since recorded increase in days to first flower with high first fruiting node with decreased in earliness index followed by Giza45 and Giza 68 genotypes.

Regarding to yield and its contributed characters Table 4 data revealed that significant differences among the ten parents. The parental genotype Giza 86 surpassed all the other parents for yield and yield components characters. This was true since this parent showed highest mean values for all yield and yield components characters followed by the promising cross Giza 89 x Pima S6 and Giza 67. On contrary, the Russian genotype (karashenecky-2) showed inferior values for all yield characters followed by Giza45, which decreased in boll weight, yield / plant, lint percentage and lint index.

With regarding to mean performance of hybrids, data illustrated in Table 5, revealed significant difference among 21 cross combinations for all earliness characters. The cross combinations which possess the Russian genotype (karashencky2) as a common parent tended to earliness, showed decreased in days to first flower with lowest first node of the first branch and highest earliness index as a compared with the other hybrids. These results might reflect the conspicuous genetic constitution of the introduced variety Karshenesky-2 which might possess much potential to improve early maturation characters. Similar results were obtained by Khedr (2002), El- Mansy (2005) and El -Mansy *et al*. (2012).

The cross combination Karsheneski2 x Giza 85 followed by Kar2 x Giza 67 surpassed all cross combinations for earliness index. On the other side the cross combination Giza 45 x Pima S6 and Giza 86 x Pima S6 showed lowest earliness index values with late maturation.

Regarding to yield and it’s contributed characters, data presented in Table 5 showed that significant difference among all cross combination for yield characters. The cross combinations Pima x 67, Pima x 86 and Pima x 68 exhibited mean values and excelled other combination for yield and it component traits. On the same trend, the cross combinations which possessed Giza 89 x Pima S6 as a common parent showed improve in boll weight as compared with other genotypes. These results might reflect the conspicuous genetic constitution of the Egyptian varieties Giza 86, Giza 67 and Dandra which may possess more potential to improve yield and its contributing characters in Egyptian cotton. This conclusion are in agreed with those reported by Abd El–Maksoud *et al* (2003) and El–Mansy *et al* (2010).

Generally the data indicated that the superiority of some cross combinations with respect to their corresponding parents. These viewpoint were kept in mind while selection these combinations as diverse F_1 base population for initiating recurrent selection for combining ability.

Table 4. Mean performance of 7 parental lines and three parental testers in earliness characters, yield and its components

Characters	Earliness traits			Yield and yield components					
	dFF	FFN	EI	BW(g)	SCY/P(g)	LCY/P(g)	LP %	SI(g)	LI(g)
Lines									
Giza 45	77.33	7.67	23.10	2.83	52.53	17.17	32.67	9.53	4.63
Giza 67	77.00	5.67	46.70	3.17	81.27	30.07	37.03	9.07	5.33
Giza 68	80.00	6.67	44.33	2.97	70.13	25.27	36.03	9.80	5.53
Giza 85	72.67	5.67	42.97	3.10	63.20	23.00	36.43	11.27	6.47
Giza 86	81.00	7.33	29.60	3.33	84.40	32.47	38.43	10.67	6.67
Dandara	73.00	5.67	49.27	2.93	68.73	25.30	36.73	10.33	6.00
Giza 92	74.33	6.33	43.13	3.33	57.70	21.37	36.97	9.27	5.43
Testers									
Karshnesky-2	65.00	4.67	75.00	2.40	51.73	17.00	32.87	7.27	3.53
Pima S6	70.33	6.00	37.50	3.30	64.83	21.87	34.90	10.27	5.50
Giza 89 * Pima S6	70.00	5.67	62.97	2.80	85.90	31.37	36.47	12.33	7.10
LSD 0.05	1.68	0.78	4.65	0.19	8.26	3.41	0.74	0.61	0.39
LSD 0.01	2.24	1.04	6.20	0.25	11.01	4.55	0.99	0.82	0.52

***dff= day first flower * ffn= Position of first fruiting node * EI= Earliness index *BW= Boll Weight * SC/P= Seed cotton /plant**
*** LY/P= Lint yield/plant * LP= lint percentage * SI = Seed index * LI= Lint index**

Table 5. Mean performance of the studied earliness, yield and its component/ characters of 21 Egyptian cotton cross combinations

	Trait	Earliness traits			Yield and yield components					
	Crosses	DFF	FFN	E I	BW(g)	SCY/P(g)	LCY/P(g)	L P%	S I(g)	L I(g)
1	K X45	66.33	6.67	66.33	2.23	57.93	18.30	32.03	9.20	4.33
2	K X67	65.00	6.00	59.40	2.90	76.63	27.33	35.70	9.27	5.17
3	KX68	66.00	5.67	70.00	2.90	60.70	21.20	35.07	9.47	5.13
4	K X85	65.67	5.33	70.87	2.30	57.40	20.20	35.30	9.60	5.27
5	K X86	65.67	6.00	66.60	3.10	67.47	23.03	34.13	9.27	4.77
6	K X D	67.67	5.67	69.40	3.17	61.97	22.50	36.33	11.43	6.53
7	K X 92	65.67	5.67	65.73	2.77	58.30	20.03	34.33	11.20	5.87
8	P X 45	69.67	7.00	38.77	3.07	81.03	28.53	35.27	10.53	5.77
9	P X 67	68.33	6.67	45.10	3.30	97.37	37.20	38.23	11.07	6.87
10	P X 68	69.00	6.67	41.23	3.13	80.27	31.03	38.60	11.13	7.00
11	P X 85	66.33	6.00	40.00	2.93	72.33	33.37	37.87	10.93	6.67
12	P X 86	69.33	6.67	39.03	3.27	76.60	27.97	36.53	10.20	5.90
13	P X D	66.67	5.67	46.80	2.97	83.17	31.77	38.27	10.20	6.30
14	P X 92	65.67	6.00	41.40	3.13	75.17	27.97	37.17	10.60	6.30
15	P*89 X45	65.33	5.33	49.77	3.27	71.67	24.47	34.13	11.40	5.90
16	P*89 X67	67.67	5.67	47.73	3.70	78.07	28.57	36.73	11.13	6.43
17	P*89X68	70.00	7.00	47.10	3.47	69.80	25.33	36.40	10.73	6.13
18	P*89X 85	66.33	5.67	46.73	3.80	72.53	29.57	37.67	11.47	6.93
19	P*89X86	71.67	7.33	46.03	3.57	63.30	22.67	35.70	12.23	6.80
20	P*89XD	67.33	6.33	53.07	3.37	77.47	29.17	37.67	11.93	7.20
21	P*89X92	68.67	5.67	49.60	3.27	81.67	29.40	36.03	12.20	6.83
	LSD 5%	1.68	0.78	4.65	0.19	8.26	3.41	0.74	0.61	0.39
	LSD 1%	2.24	1.04	6.20	0.25	11.01	4.55	0.99	0.82	0.52

***Dff=days to first flower * FFN= Position of first fruiting node * EI= Earliness index * BW= Boll Weight * SC/P= Seed cotton /plant**
*** LY/P= Lint yield/plant *LP= lint percentage * SI = Seed index * LI= Lint index**

Heterosis estimates:

The development of high yielding varieties is one of the important objectives in cotton breeding programs. The phenomenon of heterosis has provide to be the most important genetic tool in hosting the yield of self and cross pollinated crops, and is considered as the most important breakthrough in the field crop improvement, (Patel *et al.*, 2012). The study of hetrosis gives the percentage of increase or decrease of the F1 performance in terms of yield, yield contribute characters and quality characters over the mid parents or better parent or / and commercial variety.

The analysis of variance in Table 2 revealed that the mean square due to parents Vs hybrids were significant for most studied characters, indicating that the performance of parents was different from that of hybrids thereby supporting the possibility of heterotic effect for such characters.

The estimates of heterosis over better parent (heterobeltiosis) for earliness, yield and yield components are presented in Table 6. The estimates of heterobeltiosis were ranged from -3.59 % to -19.34 % for days to first flower, most cross combinations showed significant negative heterosis (desirable) over better parent for days to first flower. Out of 21 F_1 cross combinations, 5 hybrids were found significant negative heterosis (desirable) over better parent for first fruiting node and three cross combination only recorded significant positive (desirable values) heterosis over better parent for earliness index . However, most combinations showed negative values for these characters. The cross combination Kar2 x G.67 recorded the best values for all earliness traits followed by Karashencky2 x Giza86.

Improvement of yield and its contributed characters is one of the important objectives, so the superiority of hybrids over better parent is essential for increasing its commercial value. No cross combinations were surpassed better parent for all yield and its components characters. The cross combination Pima x G.68 recorded significant desirable values over better parent heterosis for seed cotton yield/ plant, lint yield and lint percentage. The cross combinations (Pima x Giza89) x G.86 and (Pima x Giza89) x Dandra exhibited significant positive heterosis for seed index and lint index.

Table 6. Heterosis over better parent (H_{BP}) for the studied earliness, yield and its components characters of 21 Egyptian cotton cross combinations

Traits	Earliness traits			Yield and yield components					
Crosses	**FF**	**FFN**	**E I**	**BW(g)**	**SCY/P(g)**	**LCY/P(g)**	**L P%**	**S I(g)**	**L I(g)**
K X45	-14.22 **	-13.04 ns	-11.56 *	-21.29 **	10.28 ns	6.60 ns	-2.54 ns	-3.50 ns	-6.47 ns
K X67	-15.95 **	-21.74 **	58.40 **	-12.12 **	18.20 ns	25.00 ns	2.29 ns	-9.74 *	-6.06 ns
KX68	-14.66 **	-26.09 **	11.17 ns	2.35 ns	-29.34 **	-32.41 **	-3.84 *	-23.24 **	-27.70 **
K X85	-14.72 **	-5.88 ns	-5.51 ns	-27.37 **	-29.37 **	-32.82 **	-4.68 **	5.88 ns	-1.25 ns
K X86	-14.72 **	0.00 ns	42.61 **	-6.06 ns	-16.98 ns	-23.39 *	-7.83 **	-9.74 *	-13.33 *
K X D	-12.12 **	0.00 ns	10.22 ns	-0.00 ns	-27.86 **	-28.27 **	-1.89 ns	-7.30 ns	-7.98 ns
K X 92	-17.92 **	-15.00 ns	-12.36 *	-6.74 ns	-16.87 ns	-20.71 ns	-4.72 **	14.29 **	6.02 ns
P X 45	-12.92 **	5.00 ns	-12.56 ns	-7.07 ns	15.54 ns	12.93 ns	-2.13 ns	2.60 ns	4.22 ns
P X 67	-14.58 **	0.00 ns	-28.37 **	11.24 *	13.35 ns	18.60 *	4.84 **	-10.27 *	-3.29 ns
P X 68	-5.05 **	17.65 ns	-45.02 **	1.08 ns	27.00 *	34.93 **	5.95 **	-1.18 ns	8.25 ns
P X 85	-8.72 **	0.00 ns	-6.90 ns	-11.11 *	11.57 ns	45.07 **	3.93 *	-2.96 ns	3.09 ns
P X 86	-4.59 *	17.65 ns	-38.01 **	5.38 ns	-10.83 ns	-10.84 ns	0.18 ns	-17.30 **	-16.90 **
P X D	-17.70 **	-22.73 **	-37.60 **	-11.00 *	-1.46 ns	-2.16 ns	-0.43 ns	-4.38 ns	-5.50 ns
P X 92	-18.93 **	-18.18 *	10.40 ns	-6.00 ns	-10.94 ns	-13.86 ns	-3.30 ns	-0.63 ns	-5.50 ns
P*89 X45	-19.34 **	-27.27 **	-20.96 **	-2.00 ns	-16.57 *	-24.64 **	-11.19 **	-7.57 ns	-16.90 **
P*89 X67	-7.31 **	0.00 ns	-36.36 **	26.14 **	13.58 ns	12.91 ns	0.00 ns	7.74 ns	7.22 ns
P*89X68	-4.11 *	16.67 ns	-4.40 ns	5.05 ns	1.55 ns	0.13 ns	-0.91 ns	3.87 ns	2.22 ns
P*89X 85	-9.13 **	0.00 ns	-25.78 **	29.55 **	-15.56 ns	-5.74 ns	2.54 ns	-7.03 ns	-2.35 ns
P*89X86	-3.59 ns	15.79 ns	-38.62 **	7.00 ns	9.71 ns	6.08 ns	-3.43 ns	32.01 **	25.15 **
P*89XD	-9.42 **	-0.00 ns	23.03 *	1.00 ns	19.49 ns	33.38 *	1.89 ns	16.23 **	30.91 **
P*89X92	-7.62 **	-10.53 ns	-21.23 **	-2.00 ns	-4.93 ns	-6.27 ns	-2.52 ns	-1.08 ns	-3.76 ns
LSD 5%	2.75	1.25	8.68	0.30	14.16	5.59	1.29	0.97	0.63
LSD 1%	3.66	1.66	11.55	0.40	18.84	7.43	1.71	1.29	0.84

***ff= first flower *ffn= first fruiting node * EI= Earliness index *BW= Boll Weight *SC/P= Seed cotton /plant**
*** LY/P= Lint yield/plant * LP= lint percentage * SI = Seed index * LI= Lint index**

Combining ability estimates:

The information on combining ability will help the cotton breeder in developing the future breeding program to be adopted for exploiting additive or/ and non-additive gene action. Such an analysis is very useful for evaluation the parental genotype to select the suitable parents to be incorporated in hybridization program, so it helps in identification of superior cross combination which may be utilized for commercial exploitation of heterosis. In the present study, an effort was made to obtain information on the magnitude of general and specific combining ability for individual parents and crosses in respect of the studied earliness, yield, fiber quality and seed quality characters through combining ability analysis.

The data illustrated in Table 2 revealed significant mean square due to general and specific combining ability for most investigated characters revealing the importance of additive and non- additive type of gene effect. However, the SCA variances were higher than GCA variances for almost all the studied characters and the ratio of σ^2 GCA / σ^2 SCA was less than unity for all the studied characters indicating the preponderance of non–additive gene action (dominance and epitasis) which is an importance in exploitation of heterosis through hybrid breeding. Similar conclusions were reported by Sawaker *et al* (2015), Shakeel *et al*, (2015) and Sivia *et al*. (2017).

The estimates of general combining ability effects of the parents for all character under study are given in Table 7. The data revealed that among the three male (testers) parents Karshenesky-2 was the best combiner for earliness index. However, it was the poorest male for boll weight, seed cotton and lint yield / plant. However, among the female parents (lines) Giza 67 was the best general combiner for earliness index. Dandra and Giza 92 were good general combiners for boll weight. The parent Giza 68 recorded significant positive general combining ability value for seed cotton yield/ plant. However the parents Giza 85 followed by Dandra gave the best general combining ability values for lint yield/plant and lint percentage.

Table 7. General combining ability effects of parental genotypes as lines and testers for earliness characters, yield and its components.

Tarit	Earliness traits			Yield and yield components					
Parent	**FF**	**FFN**	**E I**	**BW(g)**	**SCY/P(g)**	**LCY/P(g)**	**L P%**	**S I (g)**	**L I(g)**
Lines									
Giza 45	-1.56 *	-0.02 ns	12.83 **	-0.45 **	-7.33 *	-4.37 **	-1.88 **	-1.41 **	-1.22 **
Giza 67	-1.00 ns	-0.46 ns	16.54 **	-0.27 **	-10.14 **	-4.74 **	-0.90 **	-0.62 **	-0.58 **
Giza 68	0.56 ns	0.32 ns	-2.55 ns	-0.08 ns	6.48 *	1.94 ns	-0.21 ns	0.21 ns	0.07 ns
Giza 85	0.89 ns	0.32 ns	-12.33 **	-0.01 ns	3.98 ns	4.14 **	1.52 **	0.03 ns	0.42 **
Giza 86	-1.44 *	-0.46 ns	-6.43 **	-0.00 ns	4.25 ns	1.42 ns	0.37 ns	0.01 ns	0.07 ns
Dandara	0.67 ns	-0.02 ns	-5.23 **	0.53 **	1.05 ns	1.17 ns	0.78 **	0.39 ns	0.40 **
Giza 92	1.89 **	0.32 ns	-2.85 ns	0.28 **	1.72 ns	0.43 ns	0.32 ns	1.40 **	0.84 **
Testers									
Karshnesky-2	0.19 ns	0.02 ns	2.55 *	-0.17 **	-4.07 *	-2.00 *	-0.30 ns	-0.05 ns	-0.10 ns
Pima S6	-0.24 ns	0.21 ns	-2.94 **	0.01 ns	1.85 ns	1.17 ns	0.16 ns	-0.26 ns	-0.10 ns
Giza 89 * Pima S6	0.05 ns	-0.22 ns	0.39 ns	0.16 **	2.22 ns	0.82 ns	0.13 ns	0.31 *	0.20 *
LSD 0.05	1.68	0.78	4.65	0.19	8.26	3.41	0.74	0.61	0.39
LSD 0.01	2.24	1.04	6.20	0.25	11.01	4.55	0.99	0.82	0.52

***ff=days to first flower *ffn= first fruiting node * EI= Earliness index *BW= Boll Weight * SC/P= Seed cotton /plant**
*** LY/P= Lint yield/plant * LP= lint percentage * SI = Seed index * LI= Lint index**

On the basic of specific combining ability effects, results revealed that most of the combinations having significant specific combining ability effects were between genetically diverse parents as stated by El- Mansy *et al*,

(2014) and most combinations which had good specific combining ability were having one or two parents of their good x good or good x poor general combining ability.

On the basic of SCA effect for earliness characters, the cross combination Karashencky2 x Giza 92 was the best combination for most earliness characters and recorded significant desirable SCA effect values for node number of the first fruiting branch and earliness index followed by the combination (Pima x Giza 89) x Dandra for earliness index .Such crosses which included one good and one poor general combiner could produce desirable transgressive sergeants if fixable gene complex (additive) in good combiners and complementary epistatic effect in poor combiners acted in the same direction to maximize the desirable attributes. Similar conclusion was reported by El–Mansy *et al*. (2008).

The cross combination Pima x Giza67 followed by Pima x Dandra observed highest positive significant SCA effects for most yield characters. Such combinations showed significant positive heterosis over mid–parents. On the same time, the cross combination Karachenky-2 x Giza 92 recorded the poorest SCA effect values for most yield characters. For boll weight, two crosses recorded positive and significant SCA effects. The maximum SCA effect for boll weight was observed by combinations Karachenky-2 x Giza86 and Pima x Giza 86. The cross combination Karacheneky-2 x Dandra observed highest SCA effects for seed index and lint index, as shown in Table 8. Similar results were reported by Gooda (2007), El-Mansy *et al* (2014) and Sivia *et al* (2017).

Table 8. Estimates of specific combining ability effects for earliness characters, yield and its components of 21 Egyptian cotton cross combinations.

Trait	Earliness traits			Yield and yield components					
Cross	FF	FFN	E I	BW(g)	SCY/P(g)	LCY/P(g)	L P%	S I(g)	L I(g)
K X45	0.37 ns	0.54 ns	-1.46 ns	-0.27 *	-3.08 ns	-1.98 ns	-1.93 **	-0.06 ns	-0.44 ns
K X67	-0.54 ns	-0.32 ns	-2.91 ns	0.21 ns	9.69 ns	3.88 ns	1.27 **	0.21 ns	0.39 ns
KX68	0.17 ns	-0.22 ns	4.37 ns	0.07 ns	-6.61 ns	-1.90 ns	0.67 ns	-0.15 ns	0.06 ns
K X85	-0.86 ns	-0.35 ns	-0.64 ns	-0.38 **	-0.80 ns	0.28 ns	0.34 ns	-0.45 ns	-0.16 ns
K X86	-0.43 ns	0.13 ns	0.58 ns	0.23 *	3.34 ns	-0.05 ns	-1.29 **	-0.58 ns	-0.66 **
K X D	1.29 ns	0.22 ns	0.05 ns	0.15 ns	-2.53 ns	-0.23 ns	0.94 *	1.02 **	0.81 **
K X 92	-2.41 *	-0.79 ns	13.32 **	-0.11 ns	-16.53 **	-6.56 **	-1.31 **	0.32 ns	-0.20 ns
P X 45	2.02 ns	0.35 ns	-8.16 **	0.01 ns	0.28 ns	-1.23 ns	-0.84 ns	-0.14 ns	-0.30 ns
P X 67	0.40 ns	0.44 ns	-5.16 ns	0.10 ns	16.24 **	7.79 **	2.15 **	-0.18 ns	0.50 *
P X 68	0.59 ns	0.21 ns	-1.40 ns	0.19 ns	7.94 ns	2.24 ns	1.23 **	0.43 ns	0.58 *
P X 85	-1.65 ns	-0.65 ns	2.85 ns	-0.19 ns	-5.92 ns	1.41 ns	0.04 ns	0.43 ns	0.24 ns
P X 86	1.06 ns	0.44 ns	-1.45 ns	-0.00 ns	-2.02 ns	-3.65 ns	1.27*	-0.87 *	-0.82 **
P X D	0.59 ns	-0.02 ns	-1.74 ns	0.02 ns	10.57 *	5.70 **	2.04 **	-0.48 ns	0.23 ns
P X 92	0.02 ns	0.13 ns	-1.65 ns	-0.00 ns	-3.35 ns	-1.27 ns	0.48 ns	0.12 ns	0.23 ns
P*89 X45	-0.60 ns	-0.11 ns	3.39 ns	-0.01 ns	-7.22 ns	-4.42 *	-2.52 **	0.36 ns	-0.47 ns
P*89 X67	-0.52 ns	-0.46 ns	-2.00 ns	0.22 ns	8.67 ns	2.74 ns	0.10 ns	0.07 ns	0.03 ns
P*89X68	2.24 *	0.68 ns	2.85 ns	-0.20 ns	-5.52 ns	-3.66 ns	-0.70 ns	-0.12 ns	-0.27 ns
P*89X 85	-1.71 ns	-0.22 ns	-0.85 ns	-0.01 ns	-3.16 ns	0.92 ns	0.60 ns	0.05 ns	0.23 ns
P*89X86	2.25 *	0.87 ns	-6.08 *	0.34 **	-6.77 ns	-2.42 ns	-0.47 ns	0.16 ns	-0.04 ns
P*89XD	-1.65 ns	-0.32 ns	6.44 *	-0.05 ns	1.47 ns	0.92 ns	1.04 *	0.07 ns	0.36 ns
P*89X92	-0.60 ns	-0.56 ns	-0.36 ns	-0.29 *	5.30 ns	1.50 ns	-0.57 ns	-0.23 ns	-0.31 ns
LSD 0.05	2.90	1.35	8.05	0.32	14.31	5.91	1.28	1.06	0.67
LSD 0.01	3.87	1.80	10.74	0.43	19.07	7.88	1.71	1.42	0.89

***ff= first flower * ffn= first fruiting node * EI= Earliness index *BW= Boll Weight * SC/P= Seed cotton /plant**
*** LY/P= Lint yield/plant * LP= lint percentage * SI = Seed index * LI= Lint index**

It is interested to note that, the significant estimated and positive general and specific combining ability effects indicated the epistasis and / or dominance effects for F1 hybrid in cotton could be important to a certain extent. The presence of signification general and specific combining ability in F1 generation is a consequence of fluctuations in additive and dominance relationship respectively among the parents. (Basbage *et al.* 2007).

From the previous result , the SCA effects showed that the best specific combination were not always obtained from parents with good and positive GCA effects. .This finding is inconsistence with those of studies by (Lukonge *et al*. (2008) and Basage *et al*. (2009). Also, the results revealed that a higher GCA doesn't necessarily confer a higher SCA and that the GCA and SCA were independent of one another. This finding similar to those obtained by Basal *et al*. (2009) and Khan *et al*, (2009).

From the present study it could be concluded that the performance of parents does not seem to be index of general combining ability in the material genotypes. However, on the basic of GCA effects the parental lines Giza 67, Giza 68 and Giza 86 can be used as breeding lines for improvement of yield and quality characters.In the same time selection of parents for crossing programs the basic of phenotypic performance may not prove useful However, modified selection types such as recurrent selection and / or intermitting can be successfully used for carrying over and crossing the breeding mutual for the desirable characters of both yield and quality characters and thus lines developed with the accumulation of desirable genes may also act as breeding lines for heterosis breeding programs (Tuteja *et al*, 2003).

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تقديرات قوة الهجين والقدرة على التآلف لبعض التراكيب الوراثية للقطن المصري باستخدام نظام التزاوج السلالة x الكشاف

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أجريت هذه الدراسة بمحطة البحوث الزراعية بسخا بمحافظة كفر الشيخ – بمركز البحوث الزراعية خلال موسمى 2014 و 2015 على بعض التركيب الوراثية من القطن المصري (أقطان الباربادنس) وذلك بهدف دراسة متوسط الأداء وقوة الهجين بالنسبة لأفضل الأبوين والقدرة على التآلف ونوع الفعل الجيني لبعض صفات التبكير وصفات المحصول ومكوناته باستخدام نظام التزاوج السلالة x الكشاف بين سبعة أصناف كسلالات هي: جيزة 45 ، جيزة 67 ، جيزة 68 ، جيزة 85 ، جيزة 86 ، دندرة ، جيزة 92 مع ثلاث تراكيب وراثية ككشافات تشمل صنفين أجنبيين هما بيما س6 ، كارشنكاي-2 ، والهجين المبشر جيزة 89 x بيما س6. بين تحليل التباين أن متوسطات مربعات التراكيب الوراثية كانت معنوية أو عالية المعنوية لكل الصفات المدروسة مما يشير إلى وجود قدر كبير من التباين الوراثي بين التراكيب الوراثية المدروسة (الأباء والهجن). كانت متوسطات مربعات القدرة العامة على التآلف للسلالات (الآباء) معنوية لمعظم الصفات المدروسة، وفى نفس الوقت كان تباين القدرة العامة على التآلف للكشافات (الأمهات) معنوياً لصفات دليل التبكير في النضج، وزن اللوزة محصول القطن الزهر والشعر للنبات ودليل البذور ومعامل التيلة، وهذا يشير إلى أهمية تأثير الفعل الجيني الإضافي (التجميعي) والإضافي x الإضافي في وراثة هذه الصفات. أيضاً كانت متوسطات مربعات القدرة الخاصة على التآلف معنوية لكل صفات التبكير والمحصول ومكوناته المدروسة باستثناء موضع أول عقدة ثمريه، مما يشير إلى أهمية تأثير الفعل الجيني الغير إضافي (السيادي أو التفوقي) في وراثة هذه الصفات أيضاً. أظهرت النتائج أن التباين الراجع للقدرة العامة على التآلف كان أقل من التباين الراجع للقدرة الخاصة على التآلف، وكانت النسبة بينهما أقل من الواحد الصحيح لكل الصفات المدروسة، مما يشير إلى تفوق الفعل الجيني غير الإضافي (السيادي أو التفوقي) والذي يكون هام في استخدام قوة الهجين من خلال التربية بالتهجين. تفوق الهجين كارشنكاي-2 x جيزة 85 يليه الهجين كارشنكاي-2 x جيزة 67 على كل الهجن المدروسة في صفة دليل التبكير في النضج. في حين تفوقت الهجن بيما س6 x جيزة 67 ، بيما س6 x جيزة 86 ، بيما س6 x جيزة 68 على كل الهجن الأخرى المدروسة في صفات المحصول ومكوناته. سجل الهجين كارشنكاي-2 x جيزة 67 أفضل قوة هجين بالنسبة لأفضل الأبوين لكل صفات التبكير ، ويليه الهجين كارشنكاي x جيزة 86. في حين سجل الهجين بيما س6 x جيزة 86 قوة هجين مرغوبة ومعنوية بالنسبة لأفضل الأبوين لصفات محصول القطن الزهر والشعر للنبات وتصافى الحليج. كان الصنف الأجنبي كارشنكاي-2 أفضل أب مشارك عام جيد لصفات دليل التبكير في النضج ، في حين كان الصنف جيزة 67 أفضل أب مشارك عام جيد لصفة محصول القطن الزهر للنبات ، بينما كان الصنف جيزة 85 يليه الصنف دندرة أفضل الآباء قدرة عامة على التآلف لصفتي محصول القطن الشعر للنبات وتصافي الحليج. كان الهجين كارشنكاي-2 x جيزة 92 كان أفضل الهجن قدرة خاصة على التآلف لمعظم صفات التبكير، في حين كان الهجين بيما س6 x جيزة 67 يلية الهجين بيما س6 x دندرة أفضل الهجن قدرة خاصة على التآلف لمعظم صفات المحصول ومكوناته.